Water Acquisition and Management Subcommittee
Position Paper: Reservoir Evaporation Water

Introduction

- Previous assessments summarized by SSP&A for the NMISC in 2000 estimated that reservoir evaporation for Elephant Butte Reservoir over the past 50 years ranged from less than 50,000 to over 250,000 acre-feet/year, and for Cochiti Reservoir between 1976 to 1999 to range from about 5,000 to 20,000 acre-feet/year (http://www.ose.state.nm.us/water-info/mrgwss/mrgwss-final-rpt.pdf).
- This position paper presents reservoir free-water surface evaporation rates for Heron, El Vado, Abiquiu, Cochiti, Jemez Canyon, Elephant Butte, and Caballo Reservoirs calculated using pan evaporation measurement data collected near each of the reservoirs during 1985-1999. These data were obtained from the Upper Rio Grande Water Operations Model (URGWOM) web page.
- Daily pan evaporation measurements are collected year around only at Elephant Butte and Caballo Reservoirs. For Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon Reservoirs the daily pan evaporation data in the URGWOM data set include data collected from April 1 to October 31. The URGWOM data set also includes modeled estimates of daily pan evaporation for November 1 to March 31 at Abiquiu, Cochiti, and Jemez Canyon Reservoirs over the most recent 3-4 years of available data (i.e., 1996-1999).
- The URGWOM data set also includes 1985-1999 estimates for percent daily ice cover for Heron, El Vado, Abiquiu, Cochiti, and Jemez Canyon Reservoirs. These values are based on visual observations, with extrapolations projected to fill data gaps. The ice cover data are used in this position paper to estimate daily average percent free-water surface occurring on the reservoirs during the year.
- Additional data characterizing the physical attributes of the reservoirs, including reservoir spillway elevations, areas, and volume, were compiled from information obtained from various USACE and USBR web pages, plus additional information obtained directly from USBR and USACE staff for El Vado and Abiquiu Reservoirs.

Methods

- The URGWOM data set were compile in Excel spreadsheets and arranged to allow the calculation of daily averages of pan evaporation and percent reservoir ice cover using the 15-year of URGWOM data available for each reservoir (February 29 data were deleted).
- Regression-based relationships of daily pan evaporation rates were computed for the April 1 to October 31 data for both Heron and El Vado Reservoirs relative to daily pan evaporation data from Abiquiu Reservoir during the same period. Then, based on these two regression relationships, November 1 to March 31 daily pan evaporation estimates were computed for both Heron and El Vado Reservoirs using the averages for the modeled Abiquiu Reservoir daily pan evaporation available from the URGWOM data for November 1 to March 31.
- Daily estimates of surface evaporation per unit area were then computed for each reservoir using their respective daily average pan evaporation rates and a pan-evaporation correction factor of 0.7, a commonly used factor to adjust pan evaporation estimates to

surface water values. Also, for periods of ice cover, the daily free-water surface evaporation rates were calculated by multiplying by (one minus the daily percent of ice cover), as reported in the URGWOM data set.

- Estimates of maximum annual potential evaporation for each reservoir were computed using the maximum reservoir surface area at the spillway elevation and the annual total of the daily average annual evaporation rates estimated for each of the reservoirs. (Areas from available area-capacity relationships developed for each reservoir can be used to scale reservoir evaporation estimates to other areas of interest.)

Assumptions and Cautions

- Pan evaporation rates provide only approximate estimates of true reservoir evaporation rates.
- Pan evaporation rates are more affected by daily solar heating and potential shading then are natural water bodies. A constant pan evaporation correction factor of 0.7 was applied to estimate daily surface evaporation at each reservoir. However, a higher correction factor (>0.7) may be more appropriate during at least part of the year at Elephant Butte and Caballo Reservoirs, where solar heating more affects shallow surface waters.
- Placement of evaporation pans affects measured evaporation rates. For example, the evaporation pan at Heron Reservoir is located in a sparsely forested and bushy campground area, which is undoubted less affected by wind action then the reservoir. Consequently, evaporation estimates for Heron Reservoir may be greater than estimated here. Pan placement may also account for the decrease in the annual pan evaporation rates from Elephant Butte Reservoir to Caballo Reservoir.
- Estimates of percent evaporation reduction relative to Elephant Butte Reservoir, as presented below, cannot be directly evaluated in terms of likely *water savings* because actual evaporation rates are directed related to daily and seasonal operational scenarios that affect available storage and water surface areas within the reservoirs.

Reservoir/Free-Water Surface Evaporation Relationships

- Estimates of annual pan evaporation rates range from 53.2 inches/year at Heron Reservoir to 111.3 inches/year at Elephant Butte Reservoir (Table 1).
- Estimates of annual free-water surface reservoir evaporation rates range from 36 inches/year at Heron Reservoir to 77.9 inches/year at Elephant Butt Reservoir (Table 1).
- Estimates of annual free-water surface reservoir evaporation rates on a per unit area basis are as low as 46% (at Heron Reservoir) of that estimated for Elephant Butte Reservoir (Table 1).
- Estimates of *theoretical maximum* annual free-water surface reservoir evaporation rates range from 233,596 acre-feet/year at Elephant Butt Reservoir to 8,337 acre-feet/year at El Vado Reservoir (Table 1).
- *Elevation* incorporated 94% percent of the variation occurring in the estimated evaporation at the reservoirs (Figure 1). This indicates a very strong relationship between estimated reservoir evaporation rates and reservoir elevation.

Conclusions

- Significant savings of water could be possible if greater proportions of New Mexico's Rio Grande water were stored upstream of Elephant Butte Reservoir at locations of increased elevation.
- The magnitude of this saving would depend on operations and available reservoir capacities affecting the seasonal upstream storage volumes and surface areas of water stored in each reservoir.
- The information introduced here should be further developed through a subsequent study to evaluate water saving potentials under alternative reservoir operation scenarios using realistic allocations of water storage volumes and surface areas among these reservoirs for a selection of wet to dry water years. The objectives for these studies should be to define appropriate water operation alternatives to minimize reservoir evaporation losses and to maximize the conservation of water available to meet Program goals.

Table 1

Reservoir	Spillway Crest Elevation (feet AMSL)	Surface Area at Spillway Elevation (acres)*	Capacity at Spillway (AF)*	Estimated Annual Pan Evaporation (inches/year)	Estimated Annual Free-Water Surface Evaporation (inches/year)	Estimated Percent Surface-Unit Evaporation Relative to EBR	Estimated Maximum Annual Free-Water Surface Evaporation at Area of Spillway Elevation (acre-feet/year)*
Heron	7,186	5,950	401,320	53.2	36.0	46%	17,850
El Vado	6,879	2,452	196,500	60.3	40.8	52%	8,337
Abiquiu	6,350	12,430	1192801*	76.5	52.1	67%	53,967
Cochiti	5,461	9,307	582,019	91.2	61.9	79%	48,009
Jemez Canyon	5,232	2,943	97,425	103.1	71.5	92%	17,535
Elephant Butte (EBR)	4,450	35,984	2,023,400	111.3	77.9	100%	233,596
Caballo	4,182	11,532	326,670	104.3	73.0	94%	70,153

* These areas, capacities, and maximum evaporation rates are theoretical and used to provide standardized comparisons. For example, although the spillway is higher, the USACE is authorized to store only up to the 6,783.5 foot elevation in Abiquiu Reservoir, with a maximum capacity of 545,784 acre feet.

Figure 1